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Estimating the CO_2 abatement cost: Substitute Price of Avoiding CO_2 Emission (SPAE) by Renewable Energy's Feed in Tariff in selected countries

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ABSTRACT

Many renewable energy policies are looking into new incentives to absorb investments by targeting abating CO_2 emission and fixing energy price fluctuation. Feed in Tariff (FIT) is a policy for rebating the amount of generated renewable electricity to investor. FIT is also defined as a CO_2 mitigation policy in electricity generation from renewable sources. This paper presents a cost benefit survey that estimates the real produced carbon dioxide for electricity generation in selected countries. This study introduces the substitute price of avoiding CO_2 emission as an indicator. The new indicator shows how much is paid for avoiding CO_2 by each selected countries through the FIT policy for renewable technologies. The amount calculated for solar energy is taken as a case in this paper. The result confirms that the FIT policy reasonably works for solar energy in absorbing investment. However the FIT policy claims a large portion of liquidity compared with other approaches. Hence makes this mechanism inept as a CO_2 mitigation policy.

Contents

1. Introduction

Innovative policies initiatives have been formulated by many countries in order to promote the use of renewable energy technology. One of the policy initiatives is the Feed-in-Tariff program or better known as FIT. Feed in Tariff (FIT) is a policy and mechanism for accelerating the energy supply from renewable energy sources [1]. This policy guarantees grid access, a long term agreement among electricity providers, where the purchase price is indicated according to the generation cost [2]. Under this program, energy providers are paid a cost base price for the electricity they produce [1]. One of the FIT advantages often mentioned is CO_2 reduction, as an undeniable predefined objective [3]. Different countries reiterated on CO_2 mitigation perspective of the FIT policy. The Swiss FIT of Switzerland [4], Germany [5], the UK [3], Spain [6], as well as the Malaysia FIT policy [7], has especially focused on carbon reduction as one of the FIT benefits. However, as a CO_2 mitigation policy, discussing how much is paid for not producing or avoiding CO_2, as well as calculating the CO_2 emission resulting from the electricity generation, is important. This paper estimates the amount paid for avoiding CO_2 through the FIT policy in selected countries worldwide.

Natural gas, oil, diesel, and coal are energy resources that emit between 443 g CO_2e/kW h and 1050 g CO_2e/kW h [8]. Pehnt (2006) estimated the range of carbon emission in 15 separate

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Table 1
Lifecycle estimates for electricity generators [11].

Technology	Capacity/configuration/fuel	Estimate ($g CO_2e/kW h$)
Wind	2.5 MW, offshore	9
Hydroelectric	3.1 MW, reservoir	10
Wind	1.5 MW, onshore	10
Biogas	Anaerobic digestion	11
Hydroelectric	300 kW, run-of-river	13
Solar thermal	80 MW, parabolic trough	13
Biomass	Forest wood co-combustion with hard coal	14
Biomass	Forest wood steam turbine	22
Biomass	Short rotation forestry co-combustion with hard coal	23
Biomass	Forest wood reciprocating engine	27
Biomass	Waste wood steam turbine	31
Solar PV	Polycrystalline silicone	32
Biomass	Short rotation forestry steam turbine	35
Geothermal	80 MW, hot dry rock	38
Biomass	Short rotation forestry reciprocating engine	41
Nuclear	Various reactor types	66
Natural gas	Various combined cycle turbines	443
Fuel cell	Hydrogen from gas reforming	664
Diesel	Various generator and turbine types	778
Heavy oil	Various generator and turbine types	778
Coal	Various generator types with scrubbing	960
Coal	Various generator types without scrubbing	1050

Table 2
Carbon emission of the main energy resources.

Technology	Estimate ($g CO_2e/kW h$)
Hydroelectric	10
Renewable energies	41
Nuclear	66
Natural gas	443
Fuel cell	664
Diesel	778
Oil	778
Coal	1050

energy sources and renewable energy technologies [9]. Fthenakis et al. (2008) indicated that almost 29–35 $g CO_2e/kW h$ is the range of the total greenhouse gas emission for typical solar PV panels [10]. Sovacool (2008) collected the data with the nuclear carbon dioxide ranges, as shown in Table 1. Table 2 indicates the estimated ($g CO_2e/kW h$) for regular energy sources, including fossil or renewable energy sources.

Considering that the lifecycle of all renewable energies are very near to each other, and that some countries find the segregation of renewable sources very difficult to even impossible, the new table shows the highest carbon emission for coal and renewable energies assumed as the renewable energy lifecycle (Table 2).

Accordingly, the breakdown of energy calculation per country in this paper is based on the lifecycle estimates for electricity generators indicated in Table 2.

2. Energy breakdown and CO_2 emission in selected countries

Seventy five countries, states, and provinces have adapted the FIT policy [12]. European developed economies, such as Germany and France, are far ahead in fixing the rate and implementing the FIT policy in all types of renewable energies; whereas other developed economies, such as Canada and the United States, implement the policy only in certain states. Among the Asian developing economies, some have fixed the FIT rate, while other countries remain in conflict on the FIT rate.

Thirteen countries were selected from five continents based on the implementation of the FIT policy and fixed price [13]. Apart from Europe, a few countries from other parts of the world have also started their FIT payments in the solar sector [14]. However, many countries have begun to fix their rates and announce their FIT policy. Spain officially abolished its FIT payments in 2013 [15].

Malaysia is one of the Asian pioneering nations that implemented the FIT policy in solar energy sources namely the use of grid connected photovoltaic [16]. Malaysia is a tropical country with large oil and gas reserves in Southeast Asia. This country started a new approach to renewable energies almost 15 years ago through the Small Scale Renewable Energy Program [17]. However, the percentage of electricity generated from renewable energy to total electricity generation is still less than half percent [18]. The three ASEAN countries namely Malaysia, Singapore and Thailand have an inter-grid connection agreement and Thailand imports electricity mostly from Malaysia. Traditionally Thailand uses renewable sources (mainly from biomass) for their energy needs, but only 2% of Thailand's electricity is generated from biomass and biogas [19]. Moreover, Japan is the world's third largest country in electricity generation after the US and China. After the Fukushima incident, many changes were made in Japan's energy policies. When the nuclear was dropped, the government started a new renewable energy approach. Japan will increase the generated electricity from renewable energy and gas sources in the near future [20].

Germany is the first country to develop and implement the FIT policy in the world. Attention to renewable energies in government policies clearly enhances the share of these energies in the total generated electricity. To achieve this plan, Germany announced the Renewable Energy Sources Act (Erneuerbare Energien Gesetz – EEG), which guarantees a fixed tariff for all renewable energies for 20 years [21]. France is the second country in the world and first in Europe to use nuclear energy. France also benefits from the high rate of hydroelectricity [22]. Both France and Germany are industrialized countries with rich and advanced economies. Greece is under strong economic crisis, but this crisis is not a barrier to have a look at the new energy policy and the implementation of FIT in the country. Greece insists on using its own renewable sources instead of importing fossil energy [23].

Unlike in Europe, not many countries in Africa implement an FIT policy. South Africa generates more than 90% of its electricity from coal burning. The country is still able to supply the lowest electricity prices in the world at US$0.02/kW h [24]. South Africa's FIT policy was announced in 2009 for the first time by the National Energy Regulator (NERSA). Differentiated by technology, the tariffs are to be paid over a period of 20 years. Uganda is one of the poorest African countries and electricity use per capita at this country is one of the smallest in the world. However, the trend of generating electricity has changed and increased in the recent years [25]. FIT is one of the new policies in Uganda that has raised the hopes of local governors.

In Central and South America, only four countries have an FIT policy and a fixed rate for solar tariff. Argentina aims to source out 8% of its energy from renewable energies by 2016 [26]. This percentage is equal to 3000 MW, 10% of which will come from solar energy. The country's FIT policy was implemented in 1998 to support wind and solar technologies but was replaced in 2006 for a 15-year-period tariff for different types of renewable energies [27]. Another South American country used in this study is Ecuador which remains hopeful in increasing the share of renewable energy by implementing the FIT mechanism [28]. Ecuador adapted the policy in 2011which is including solar, biomass, biogas and hydro projects are further differentiated by size [29].

Argentina generates 61% of its electricity from conventional thermal plants that primarily burn natural gas. The country imported 2412 GW h of power from its neighboring countries in 2011, which is almost 2% of the country's total need.

Although the United States, Canada, and Australia are among the advanced countries using renewable energy and implementing the policies, FIT is not implemented throughout the country, but only on some states or provinces. Nonetheless, the total data are shown in Table 3. Discussions on FIT details are limited in some areas, namely, Vermont (United States), Victoria (Australia), and Ontario (Canada).

Table 4 shows the latest demand for electricity in the selected countries in 2013. It is total demand based on per capita consumption in each selected countries. The population and electricity per capita (kW h) as secondary data has been collected from World Atlas and World Bank 2013. It shows the population, and electricity per capita consumption and total electricity generated. Among these countries the people of Uganda use the lowest electricity per capita at 68 kW h, whereas Canadians use 16406 kW h of electricity per year. The table also indicates that the total demand for electricity in 2013 for Uganda is less than 3000 GW h. Furthermore, the United States has more than 4 million and Japan has almost one million GW h. The Thai people use 2316 kW h electricity per capita when this amount for Malaysia is 4246 and The Ecuador people use only 1192 kW h.

The share of each primary source in CO_2 emission for the selected countries shown in Table 3 has been calculated and shown in Table 5.

Table 5 indicates that the carbon dioxide produced per capita in the United States is nine times more than that in France, more than six times larger than that in Thailand, and double the values in Canada and Germany. Nuclear energy accounts for more than 76% of the electricity in France, resulting to one of the lowest CO_2 production in the world. South Africa uses the highest percentage of coal in electricity generation, which produces the most CO_2 among energy sources. Moreover, the highest share of generated electricity by renewable energy belongs to Uganda then Germany, whereas the highest amount of electricity and also CO_2 is produced by the United States.

3. CO_2 abatement cost throughout the FIT policy implementation in selected countries

The FIT policy has various dimensions and coverage in different countries. Countries, such as Germany and Greece, have the most renewable energy sources within the country covered by FIT. However, others such as Japan implement FIT only for Geothermal, Wind, and Solar energy. Table 6 summarizes the FIT rates in the countries that have been selected for the study. The FIT policy in the United States, Australia, and Canada is not implemented in all states. The FIT rates differ across similar energy sources in various areas.

Notably, the above prices or FIT rates are fixed in local currency, such that any change in the world currency affects our table. In addition, the degression rate serves as an effective base of FIT in some countries given the current price, indicating that the countries that have started the FIT mechanism earlier suffer more degression in the current price.

Table 6 shows the effort of different countries to abate or reduce carbon dioxide. Avoiding CO_2 incurs between US$0.001 and US$0.8 for each kW h across the countries. The highest payment belongs to the Victoria state of Australia, where the payment for wind, hydro, biomass, and solar is fixed in 2013. Other countries have chosen other approaches, and have indicated different prices for different types of renewable energies. Argentina received the lowest payment at almost US$0.001 for electricity generated from biogas, biomass, and wind. Converting the above amounts confirms that the rate of avoiding CO_2 production in selected countries is between US$0.055 and US$0.576 per kW h. Table 7 indicates the average of produced CO_2 for one kW h of electricity in the selected countries. For instance, The Thai government pays

Table 4
Total electricity need for selected countries for 2013.

Country	Population[a]	Electricity[b] per capita kW h	Total generated electricity GW h
Peninsular Malaysia	23,500,000	4246	99,781
Thailand	63,525,062	2316	147,142
Japan	127,380,000	7848	999,678
Germany	81,757,600	7081	578,925
Greece	11,306,183	5296	59,877
France	65,447,374	7289	477,046
Uganda	33,796,000	(68)[c]	2298
Ecuador	14,228,000	1192	16,960
United States	309,975,000	13,246	4,105,928
Canada	34,207,000	16,406	561,200
Australia	22,421,417	10,720	240,358
South Africa	48,601,098	4694	228,134
Argentina	42,610,981	2967	126,427

[a] All population data were extracted from World Atlas, April 2013.
[b] All data were collected from World Bank, 2013.
[c] [41].

Table 3
Primary energy use for electricity generation in selected countries.

Country	Natural gas (%)	Coal (%)	Nuclear (%)	Hydro (%)	Crude oil (%)	Renewable (%)	Total
Peninsular Malaysia [30]	65	29	0	6	0	0	100
Thailand [2]	71	21	0	5	1	2	100
Japan [3]	27	28	17	17	10	1	100
Germany [4]	11	45	16	4.5	1.5	22	100
Greece [32]	27	56	0	8	5	4	100
France [33,34]	4	4	76	12.5	1	2.5	100
Uganda [25]	0	0	0	62.3	0	37.7	100
Ecuador [35]	48	0	0	40	0	2	90[a]
United States [36]	24.8	42.2	19.2	0	7.9	5.9	100
Canada [37]	5	15	15	60	3	2	100
Australia [38]	16.1	64.6	0	16.3	0	3	100
South Africa [39]	0	90	5	5	0	0	100
Argentina [40]	61	0	5	32	0	0	98[b]

[a] 10% of Ecuador electricity is imported from Columbia and Peru [35].
[b] 2% of Argentina electricity is imported from Paraguay [40].

Table 5
Produced CO_2 based on electricity primary shares for selected countries.

Country	Natural gas (443)	Coal (1050)	Nuclear (66)	Hydro (10)	Crude oil (778)	Renewable (41)	Total produced CO_2 for electricity use (megaton)	Produced CO_2 for electricity kg/capita
Peninsular Malaysia	28.732	30.383	0	0.060	0	0	59.175	2518
Thailand	46.280	32.445	0	0.073	1.145	0.120	80.063	1260
Japan	119.571	293.905	11.216	1.699	77.775	0.410	504.576	3961
Germany	28.211	273.542	6.113	0.260	6.756	5.222	320.104	3915
Greece	7.163	35.207	0	0.047	2.329	0.098	44.844	3966
France	8.453	20.035	23.928	0.60	3.711	0.489	57.216	874
Uganda	0	0	0	0.014	0	0.035	0.049	1.45
Ecuador	3.606	0	0	0.067	0	0.014	3.687	259
USA	451.093	1819.336	52.030	0	252.358	9.932	2584.749	8339
Canada	12.431	88.389	5.556	3.367	13.098	0.46	123.301	3605
Australia	17.143	163.035	0	0.391	0	0.296	180.865	8067
South Africa	0	215.587	0.752	0.114	0	0	216.453	4454
Argentina	34.164	0	0.417	0.405	0	0	34.986	821

Table 6
Price summary for renewable energy FIT (US$/kW h).

Country	Small wind	Wind	Offshore wind	Geothermal	Biomass	Biogas	Hydro	Small solar	Large solar
Malaysia [42]	–	–	–	–	0.10	0.101	0.080	0.370	0.25
Thailand [43]	–	0.117–0.150	–	–	0.017	0.017	0.027–0.050	0.217	–
Japan [44]	0.709	0.284	–	0.33–0.51	–	–	–	0.52	0.382
Germany [45]	–	0.121	0.202	0.337	–	0.193	0.171	0.388	0.298
Greece [46]	0.337	0.118	0.131	0.202	0.110	0.297	0.119	0.640	–
France [47]	–	0.111	0.175	0.270	0.169	0.182	0.074	0.626	0.162
Ontario (Canada) [48]	–	0.131	–	–	0.134	0.190	0.127	0.780	0.431
Vermont (US) [49]	0.2	0.125	–	–	0.125	0.160	0.125	0.300	–
Victoria (Australia) [50]	0.8	0.8	–	–	0.8	–	0.8	0.8	–
Uganda [51]	–	0.124	–	0.077	0.103	0.115	0.109	0.362	–
Ecuador [52]	–	0.091	–	0.132	–	–	0.072	0.400	–
South Africa [53]	–	0.11	–	–	0.10	0.08	0.08	0.35	0.21
Argentina [54]	0.001	0.001	–	–	0.001	0.001	0.001	0.12	–

Table 7
Average CO_2 emission for 1 kW h of generated electricity.

Country	Aco_2 (g CO_2/kW h)
Peninsular Malaysia	593
Thailand	544
Japan	505
Germany	553
Greece	749
France	120
Canada	220
United States	630
Australia	752
Uganda	21
Ecuador	217
South Africa	949
Argentina	277

US$0.424 only for avoiding one kg CO_2 production through the FIT mechanism, but the Australian government is paying US$1.11 to not produce one kg CO_2 from the same biomass source (the amount of CO_2 for biomass has been assumed to be 41 in all calculations).

Different countries are paying different prices for avoiding CO_2 emission in the electricity generation of renewable energy sources. The price of avoiding one ton of CO_2 emission in different countries is different. Thus, this research is introducing, for the first time, an indicator as "Substitute Price of Avoiding CO_2 Emission by Renewable Energy for Electricity generation" (SPAE). Another useful indicator, the "Substitute Price of Avoiding CO_2 Emission" (SPAC), is also created.

The following are followed to reach the indicators:

- Total produced CO_2 for generating electricity in X country: Tco_2;
- Total generated electricity within one year in X country: Tge;
- Average CO_2 emission for 1 kW h of generated electricity in X country: Aco_2;
- Average CO_2 emission avoidance in X country after replacing by renewable energy source: $AAco_2$;
- Substitute price of avoiding CO_2 emission by Renewable Energy for 1 kW h Electricity: SPAE.
- Tariff rate for selected renewable energy in X country is Tp.

Thus,

1) $[Tco_2$ (Ton CO_2/annum)/Tge (GW h/annum)$]=Aco_2$(kg);
2) Aco_2(kg) $-$ [Estimate (kg CO_2e/kW h)] $= AAco_2$(kg);
3) $[AAco_2$(kg) $\times$ Tp(US$/kW h)$]=$ SPAE US$/(kg CO_2e/kW h);
4) [1000 kg/$AAco_2$(kg)] $\times$ Tp(US$/kW h) $=$ SPAC (US$/ton CO_2)or
5) [1000 kg $\times$ Tp(US$/kW h)]/$AAco_2$(kg) $=$ SPAC (US$/ton CO_2).

For instance, the trend of SPAC price calculation for Japan is as follows:

1) $504.576/999{,}678=0.505$: Aco_2;
2) $0.505-0.032=0.473$: $AAco_2$;

3) $0.473 \times 0.520 = 0.246$: SPAE;
4) $1000 \times 0.520/0.473 = 1099$: SPAC.

It means that through the solar FIT policy, Japan pays US$1099 for not producing one ton of CO_2.

Table 8 indicates the substitute price of avoiding one ton of CO_2 emission [(SPAC) (tone CO_2/US$)] for the selected countries using a solar source. This table shows other SPAC for other renewable energies by replacing Tp and lifecycle estimates for the electricity generators (kg CO_2e/kW h) of the other renewable energies.

Table 8 shows the final rate of the solar FIT payment in selected countries for avoiding the production of one ton of carbon dioxide in using solar as an electricity generator. Table 8 shows the SPAE in the breakdown of energy sources in each country. The SPAE by Renewable Energy for one kW h of Electricity in Malaysia is US $0.207; whereas the amount for Victoria in Australia is US$0.576. The amount for Uganda cannot be calculated because all electricity sources of Uganda are from hydro, with CO_2 emission less than the renewable sources.

Perhaps SPAE cannot clearly explain the payments of countries for avoiding carbon emission. However, SPAC can clearly clarify the rationale behind the rate of solar FIT for avoiding each ton of CO_2. The last column in Table 8 indicates that the highest payment comes from France, which pays more than US$7000 for not producing each ton of CO_2. After France, Ontario in Canada pays more than US$4000 for avoiding each ton of CO_2, followed by Ecuador with US$2162. South Africa pays only US$382 for each ton of CO_2, Thailand US$424, and Argentina US$449, indicating that the selected countries pay between US$7114 and US$382 for not producing one ton of CO_2 according to the country's rate of solar FIT.

The rationale here depends on each country's method of producing CO_2 and the fixed price for FIT. Considering that 76% of France's electricity is generated from nuclear energy, which produces carbon dioxide at a very low level [55], avoiding the remaining carbon in the country will be very expensive. Meanwhile, avoiding CO_2 emission in a country such as South Africa where 90% of its electricity is generated from coal costs only US $382. The attention provided to Aco_2 of each country is shown in the second column, except for Uganda whose people currently lack access to electricity. France produces the least CO_2, followed by Ecuador and Ontario of Canada. Although we can provide some examples of low carbon production and high SPAC, it cannot be a rule as Table 8 shows because a country such as Argentina produces only 277 g of CO_2 per kW h although its SPAC is less than that of countries with high Aco_2 because of the small fixed rate of FIT.

4. CO_2 abatement cost by different approaches

In Europe, the marginal cost of carbon emission avoided is 40 Euros per ton. In addition, the estimated cost of gradual carbon capture drop until 2030 reaches up to 20–30 Euros per ton [56]. The International Association for Energy Economics analysis indicated that the cost of implementing the Kyoto Protocol in the United States is less than US$26 per ton. This Association anticipated that the cost of carbon dioxide emission in the United States will increase up to US$250 under worse situations [57]. In 2007, Mc Kinsey & Company reported that the average CO_2 cost in the US is less than US$50 [58]. However, the approximate amount of the global CO_2 abetment cost is US$35 per ton [59].

The Average Implicit Abatement Subsidy (AIAS) is another indication that clears the country's payments for abating carbon emission. The cost of effectiveness of the set of policies in achieving abatement is observed [60]. Table 9 shows the results of Australian productivity commission (2011), which indicates the AIAS in their selected countries. Four countries, namely, Australia, Germany, Japan, and the United States, are common between our research and productivity commission's research.

The comparison of the AIAS and SPAC between the four countries is shown in Tables 8 and 9, confirms that the countries avoiding one tone emission by FIT payment are suffering higher costs. For Japan and Germany, this cost is almost 4 times, almost 10 times for the United States, and 11 times for Australia.

5. Conclusions

Many researchers have shown different rates of carbon emission for energy carriers and renewable sources. Understanding the rate of CO_2 emission in each country for generating electricity necessitates some primary data on the breakdown of electricity sources in each country. However, numerous countries, states and provinces in the world are paying a subsidy for FIT, which is a CO_2 reduction in the world. A survey of the 13 solar FIT-paying

Table 9
Average implicit abatement subsidy [60].

Country	US$/t CO_2
Australia	44–99
Germany	137–175
Japan	156–287
United States	43–50

Table 8
Countries' payment for avoiding one ton of CO_2 emission by solar technology.

Country	Tp (US$)	Aco_2 (kg CO_2/kW h)	Solar emission (kg CO_2e/kW h)	$AAco_2$ (kg)	SPAE US$/ (kg CO_2e/kW h)	SPAC (US$/ton CO_2)
Peninsular Malaysia	0.370	0.593	0.032	0.561	0.207	660
Thailand	0.217	0.544	0.032	0.512	0.111	424
Japan	0.520	0.505	0.032	0.473	0.246	1099
Germany	0.388	0.553	0.032	0.521	0.202	745
Greece	0.640	0.749	0.032	0.717	0.458	893
France	0.626	0.120	0.032	0.088	0.055	7114
Ontario (Canada)	0.780	0.220	0.032	0.188	0.146	4149
Vermont (US)	0.300	0.630	0.032	0.598	0.179	502
Victoria (Australia)	0.800	0.752	0.032	0.720	0.576	1111
Uganda	0.362	0.021	0.032	–	–	–
Ecuador	0.400	0.217	0.032	0.185	0.074	2162
South Africa	0.350	0.949	0.032	0.917	0.320	382
Argentina	0.110	0.277	0.032	0.245	0.270	449

countries from 5 continents indicated the amount of CO_2 emission of each country for generating electricity, in total and per capita. The highest produced CO_2 per capita belongs to the United States which is 8339 kg annually. Ugandans in Africa have the lowest electricity consumption (or access) among the selected countries, producing only 1.45 kg of CO_2 per capita per year due to the use of hydropower for electricity generation. The average of produced CO_2 for one kW h in each country was calculated. South Africa produces the highest rate of CO_2 per kW h, that is, almost 950 g. Australia produces 752 g of CO_2 per kW h, Greece produces only 749 g, and the United States produces 630 g. France is the only country that produces 120 g of CO_2 per kW h. The FIT rate per kW h indicates the amount each country pays for not producing CO_2 per kW h. Accordingly, two new indicators, namely, Substitute Price of Avoiding CO_2 Emission by Renewable Energy for Electricity Generation (SPAE) and Substitute Price of Avoiding CO_2 Emission (SPAC), have been recommended for renewable energies. SPAE shows that governments in selected countries pay between US $0.074 and US$0.576 for not producing CO_2 per kW h. SPAC indicates that countries pay US$382–7114 for avoiding one ton of CO_2 emission. A comparison between solar FIT payment and other CO_2 abatement costs shows that governments are incurring higher payment of liquidity with FIT as a carbon mitigation policy and that cheaper alternatives are available. Replacing other renewable energy lifecycles and tariffs in the SPAC trend indicates the final substitute price for avoiding one ton CO_2 emission of any renewable sources.

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